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ABSTRACT

As part of the new Victorian Certificate of Education, the state of Victoria, Australia, implemented changes to secondary mathematics courses in order to cater to the needs and aspirations of all students by using a variety of teaching and assessment strategies. The first year that the changes were fully implemented for grade 12 was 1992. A statistical analysis examined the influence of locale (rural versus urban) and sex of student on mean achievement on the various Common Assessment Tasks (CATs). There were 6 mathematics subjects in year 12, attended by 19,413 females and 22,567 males, for which there were four CATs. CATs 1 and 2 required the students to communicate their findings in written reports, were assessed within the school by their teacher, and were performed over an extended period of time. CATs 3 and 4 were multiple-choice and extended-answer examinations respectively, and were marked externally. Findings indicate that females were not as disadvantaged in mathematics assessment as they had been in earlier mathematics courses in Victoria. The largest disadvantage for females occurred in terms of participation, particularly in advanced mathematics courses. Females generally performed better than males in CATs 1 and 2, and males generally performed better than females in CATs 3 and 4. There was a significant regional effect in that rural students, particularly males, performed worse than their metropolitan counterparts in CATs 1, 2, and 3. Implications concerning equality of opportunity and gender differences in test taking are discussed. Seventeen tables and four graphs depict data and results. (Contains 36 references.) (TD)

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ED 425 027

REGIONAL AND GENDER DIFFERENCES IN VARIOUS FORMS OF MATHEMATICS ASSESSMENT WITHIN THE VICTORIAN CERTIFICATE OF EDUCATION

PETER COX

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RC 021480

Regional and Gender Differences in Various Forms of Mathematics Assessment at Year 12 Level

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Abstract

This paper reports on the findings of a statistical analysis of the 1992 year 12 Victorian Certificate of Education (VCE) mathematics data, to establish, by examining locale (country versus metropolitan), and sex of student, if gender differences in mean achievement of males and females on the various Common Assessment Tasks (CATs) were present. In all six mathematics subjects in year 12, in 1992, there were four CATs. CATs 1 and 2 required the students to communicate their findings in written reports and were assessed within the school by their teacher and were performed over an extended period of time. CATs 3 and 4 were multiple-choice and extended-answer examinations respectively, and were marked externally.

The findings indicated that females generally performed significantly better than males in CATs 1 and 2 and males generally performed significantly better than females in CATs 3 and 4. There was a significant regional effect with the country students, particularly males, performing less well than their metropolitan counterparts in CATs 1, 2 and 3.

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Introduction

The study of gender differences in senior secondary school mathematics achievement has been explored in great detail and findings indicate that at senior secondary level males generally perform better than females on multiple-choice items (Sharma and Meighan 1980; Stobart, Elwood and Quinlan 1992; Whitehouse and Sullivan 1992; Willis 1989) and external examinations (Lydeamore 1993; MacCann 1995; Stobart et al. 1992; Whitehouse and Sullivan 1992; Willis 1989). However, school-based assessment and course-work components of mathematics assessment have been shown to favour females (Kimball 1989; Lydeamore 1993; MacCann 1995; Parker in Rennie and Parker 1991; Stobart et al. 1992; Whitehouse and Sullivan 1992).

The Victorian Certificate of Education

In 1992, when the new Victorian Certificate of Education (VCE) was fully introduced at Years 11 and 12 in the state of Victoria, Australia, new mathematics subjects and forms of assessment were in place. The underlying philosophy behind the changes to mathematics was to create a course that catered for the needs and aspirations of all students by using a variety of teaching and assessment strategies (Blackburn 1985). There were six distinct Units 3 and 4 (Year 12) mathematics subjects in the VCE. These were

Space and Number Units 3 and 4 (S&N),

Extensions Space and Number Units 3 and 4 (Ext. S&N),

Change and Approximation Units 3 and 4 (C&A),

Extensions Change and Approximation Units 3 and 4 (Ext. C&A),

Reasoning and Data Units 3 and 4 (R&D) and

Extensions Reasoning and Data Units 3 and 4 (Ext. R&D).

For all six mathematics subjects available at Year 12 level in 1992, students were assessed using four Common Assessment Tasks (CATs). The first two CATs were internally assessed and were performed over an extended period of time; the last two CATs were in the traditional examination style. A brief description of each of the CATs follows.

CAT 1 Investigative Project: a 1500 word written report based on an independent mathematical investigation.

CAT 2 Challenging Problem: in this project the student selected one of four set problems and used a number of problem solving strategies and/or modelling to prepare a report including a solution.

CAT 3 Facts and Skills Task: a multiple-choice examination which consisted of forty-nine multiple-choice questions.

CAT 4 Analysis Task: an examination designed to test interpretation and analysis of between four and six short-answer questions, involving solutions of increasing complexity (Victorian Curriculum and Assessment Board 1990).

Student performance on all CATs was reported using eleven letter grades, descending from A+ to E and UG (ungraded); an E was considered a basic pass.

Country Versus City Schooling

Canadian studies by Randhawa (1988) found that Year 10 males and females from rural classrooms performed similarly on tests of computation but in the urban classrooms males were better than females on tests of computation. Further to this, Randhawa's (1988) and Randhawa and Hunt's (1987) data indicated that students from rural classrooms achieved better on mathematical concepts than those from urban classrooms. In contrast to these findings, Methen and Wilkinson (1988) studied Year 12 students in Kuwait. They found that males in rural schools did no better than their urban counterparts in mathematics, but the females in urban schools attained higher average scores in mathematics than did their rural counterparts.

Some context specific differences in terms of gender and locale are also backed up by the Second International Mathematics Study (Ethington 1990), which showed variable gender differences in countries suggesting a societal rather than a genetic relationship.

Teese, Davies, Charlton and Polesel (1995) reported on Australian mathematics data relating to regional and socio-economic dimensions of gender outcomes. They found that performance levels of country students in examinations were lower than those of most urban students, and that, in the country and higher status suburbs, females have better results than do their male counterparts, but not in the intermediate status suburbs. Gilbert (1995) also reported that Years 3, 7 and 10 Western Australian students from metropolitan schools outperformed rural and remote students in mathematics.

The different results for different countries back up the suggested sociocultural effect put forward by Swetz, Langgulung and Johar (1983), Randhawa (1988) and Methen and Wilkinson (1988) to explain differences in achievement between urban and rural students.

Teese et al. (1995) and a South Australian report (Whitehouse and Sullivan 1992) found that large and significant locational differences were present in Year 12 examination results for mathematics and all science subjects; these differences indicated that country candidates were disadvantaged judging by their examination grades. It appears that not only grades were affected; the National Report on Schooling in Australia (Australian Education Council 1993, p. 21) reported that students from remote schools were 18% less likely to complete Year 12 than

urban or rural students, who were very similar in their Year 12 completion rates. Whitehouse and Sullivan (1992) suggested that an inequality of opportunity for country students was caused by factors such as a lower quality of the educational experiences that promote success in examinations. Smaller school size was another factor which Whitehouse and Sullivan (1992) suggested limited students' subject choices and resources, and teachers from country schools were often less experienced and found it more difficult to access training, development, and in-services than did their metropolitan counterparts.

Method

This study used the 1992 VCE mathematics data. For the purposes of this study the eleven point grading scale (A+, A, ... , E, UG), used in reporting VCE Units 3 and 4 CAT grades, was converted to a score out of 10 (i.e. A+ = 10, A = 9, ... , E=1, UG = 0).

The data were separated into the differing mathematics subjects and analysed using descriptive statistical procedures such as graphs and averages. Inferential statistical methods used included MANOVA and resulting univariate F-tests. The multivariate statistic used to test the significance of main effects and interactions was the Pillai's criterion because of its robustness (Tabachnick and Fidell 1989, p. 399; Hedderson 1987, p. 119). Unequal cell sizes were not equalised; however, the SPSS-X MANOVA program adjusted for the unequal cell sizes in calculations using the sequential approach (Tabachnick and Fidell 1989, p. 404). Multiple MANOVA tests were carried out for the six VCE mathematics Units 3 and 4 subjects and so an adjustment was needed for inflated Type I error rate, or α. Consequently a conservative estimate (Stevens 1992) of the adjusted α value was made using a Bonferroni adjustment (Stevens 1992; Tabachnick and Fidell 1989).

Questions related to gender performance on the various CATs were explored and in each case the corresponding participation figures were examined. The following questions are addressed in sections outlined below:

1. Do females and males differ in their mean performance on the CATs?
    (a) Participation of males and females in VCE mathematics.
    (b) Gender differences in performance.
2. Do females and males, from country and metropolitan schools, differ in their mean performance on the CATs?
    (a) Participation of country and metropolitan males and females in VCE mathematics.
    (b) Differences between student performance in country and metropolitan regions.

(c) Intra-regional performance differences between males and females in country and metropolitan schools.

(d) Inter-regional performance differences between males and females in country and metropolitan schools.

Results

1. Do Males Differ from Females in VCE Units 3 and 4 Mathematics with Respect to their Mean Performance on CATs 1 to 4 ?

(a) Participation of Males and Females in VCE Mathematics

The numbers of students enrolled in each of the six Units 3 and 4 subjects are presented in Table 1, with a break-down of the number of males and females presenting for CAT 1.

Table 1. Number and Percentage of Females and Males Assessed for CAT 1 for each of the Six Units 3 and 4 Subjects

	CAT 1			
Subject	N(F)	N(M)	%(F)	%(M)
S&N	3558	3623	12.6	15.0
Ext. S&N	2351	2302	8.3	9.5
C&A	3349	2605	11.9	10.8
Ext. C&A	4009	6376	14.2	26.4
R&D	6079	7576	21.6	31.4
Ext. R&D	67	85	0.2	0.4

Because of the different number of females and males taking Units 3 and 4 VCE, the percentages of the total VCE Units 3 and 4 population of females and males in each mathematics subject are also presented in Table 1. The percentage values in each column do not sum to 100% because students taking two or more subjects are counted more than once. From the percentage values in Table 1, it can be seen that there was a higher proportion of males doing all mathematics subjects at VCE in 1992 except for C&A. This small female advantage in percentage enrolment in C&A is overshadowed by the more demanding Ext. C&A in which the percentage enrolment is considerably more for males than for females.

(b) Gender Differences in Performance on the CATs

The average numerical scores of the male and female populations within each subject were

calculated for each CAT. The results are presented in Table 2.

Table 2. Average Scores Gained by Females and Males in each of the Four CATs for each of the Six Units 3 and 4 Subjects

	CAT 1		CAT 2		CAT 3		CAT 4	
Subject	F	M	F	M	F	M	F	M
S&N	4.82	4.61	5.32	5.35	5.05	5.63	3.97	4.94
Ext. S&N	4.36	3.52	4.89	4.15	2.93	2.65	3.20	3.07
C&A	6.35	5.92	6.54	6.38	5.29	5.55	6.13	6.25
Ext. C&A	6.73	6.17	6.79	6.65	5.76	5.95	5.61	6.09
R&D	5.51	5.20	5.96	5.99	5.72	6.09	4.49	5.07
Ext. R&D	5.84	5.18	6.60	5.65	3.22	3.19	4.63	5.18

Table 2 provides important information regarding the relative scores of males and females on the different CATs but is in a difficult form to observe the overall trends. Consequently, the difference between the female average and the male average was calculated and is presented graphically in Figure 1 by plotting the difference (female mean minus male mean) in CAT scores for each CAT within each study.

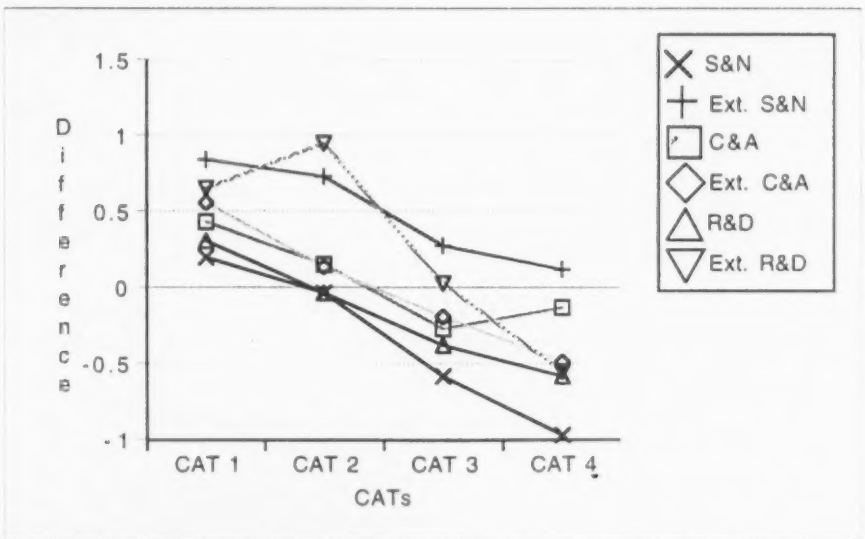

Figure 1. Graph of difference (female average CAT score minus male average CAT score) for each CAT, by subject.

From Figure 1 it can be seen that there is a similar downward trend in the difference for all

subjects across the CATs.

A one-factor (sex) MANOVA model was employed to analyse the data. A significant sex-effect ($p \leq 0.05$) for all four CATs was observed in all six subjects. The results of these tests are summarized in Table 3.

Table 3. Results of the MANOVA for Sex Effect in the Six Units 3 and 4 VCE Mathematics Subjects

Subject	d.f.	F (Exact)
S&N	4, 6642	134.1 **
Ext. S&N	4, 4103	44.9 **
C&A	4, 5740	34.8 **
Ext. C&A	4, 10013	123.5 **
R&D	4, 12634	139.6 **
Ext. R&D	4, 123	4.3 *

* adjusted $p \leq 0.05$ ** adjusted $p \leq 0.01$

The resultant univariate tests displayed significant differences ($p \leq 0.05$) in many of the CATs. The summary of these tests is provided in Table 4. The univariate tests in Table 4 indicate that there were statistically significant performance differences in favour of females in four of the subjects for CAT 1, three of the subjects for CAT 2 and one subject for CAT 3. Significant performance differences in favour of males occurred in four of the subjects for CAT 3 and three subjects for CAT 4. In all but one of the cases above, females were performing significantly better than males only on verified CATs and in all cases males were performing significantly better than females only on test CATs.

Table 4. Results of the Univariate Tests for Sex Effect on Achievement for each CAT in each of the Six Subjects

		Univariate F values			
Subject	d.f.	CAT 1	CAT 2	CAT 3	CAT 4
S&N	1, 6645	4.7	3.8	162.7 *m	364.8 *m
Ext. S&N	1, 4106	130.7 *f	88.3 *f	18.0 *f	2.0
C&A	1, 5743	54.5 *f	6.4	21.0 *m	3.7
Ext. C&A	1, 10016	137.9 *f	9.6 *f	17.7 *m	101.8 *m
R&D	1, 12637	35.5 *f	2.0	135.0 *m	282.7 *m
Ext. R&D	1, 126	3.7	7.6 *f	0.0	2.4

* adjusted $p \leq 0.05$ (f in favour of females; m in favour of males)

2. Do Males Differ from Females in VCE Units 3 and 4 Mathematics with Respect to their Mean Performance on CATs 1 to 4 when the Location (Country Versus Metropolitan) of their Schools is Taken into Account?

(a) Participation of Country and Metropolitan Males and Females in VCE Mathematics Units 3 and 4 Subjects

Students were classified according to the region in which their school was placed. The three metropolitan regions were separated from the country regions. The number of female and male students in the country and metropolitan regions enrolled for CAT 1, and the female, male, and combined female and male percentages of their respective country or metropolitan population are summarized in Table 5. There were many more VCE Units 3 and 4 students in the Melbourne metropolitan area (20640 females and 17908 males) compared to the country regions (7564 females and 6212 males) (Victorian Board of Studies 1996).

There were larger percentages of country students studying Ext. S&N and R&D. However, there were larger percentages of metropolitan students studying the remaining four subjects.

Table 5. Summary of the Country and Metropolitan Male and Female Students by Number and Percentage of Their Total Regional VCE Male, Female, or Combined Population for CAT 1 in the Six VCE Units 3 and 4 Subjects

	N(country)		N(metro.)		%(of country)			%(of metropolitan)		
Subject	F	M	F	M	F	M	ALL	F	M	ALL
S&N	945	758	2612	2863	12.4	12.2	12.3	12.6	15.9	14.2
Ext. S&N	708	681	1643	1621	9.4	10.9	10.0	8.0	9.1	8.5
C&A	631	454	2718	2151	8.3	7.3	7.9	13.1	12.0	12.6
Ext. C&A	964	1458	3044	4915	12.7	23.4	17.5	14.7	27.4	20.6
R&D	1777	2223	4301	5351	23.4	35.7	29.0	20.8	29.8	25.0
Ext. R&D	17	16	50	69	0.2	0.3	0.2	0.2	0.4	0.3
OVERALL					59.2	70.6	64.4	61.0	72.4	66.3

(b) Differences Between Student Performance in Country and Metropolitan Regions

To assess the trends for both country and metropolitan students the average scores for country and metropolitan students were calculated and are presented in Table 6.

Table 6. Average Scores for Country (C) and Metropolitan (M) Students in All CATs for All Subjects.

	CAT 1		CAT 2		CAT 3		CAT 4	
Subject	C	M	C	M	C	M	C	M
S&N	4.31	4.84	4.88	5.47	4.97	5.46	4.27	4.51
Ext. S&N	3.95	3.94	4.69	4.46	2.76	2.81	3.34	3.05
C&A	5.88	6.23	6.35	6.50	5.14	5.46	5.99	6.23
Ext. C&A	6.12	6.47	6.48	6.77	5.56	5.97	5.90	5.91
R&D	5.32	5.34	5.89	6.01	5.94	5.92	5.01	4.73
Ext. R&D	5.88	5.35	5.94	6.11	2.84	3.30	4.50	5.05

The differences between the country and the metropolitan average scores were calculated by subtracting the metropolitan average CAT grade from the country average CAT grade. The results are plotted in Figure 2.

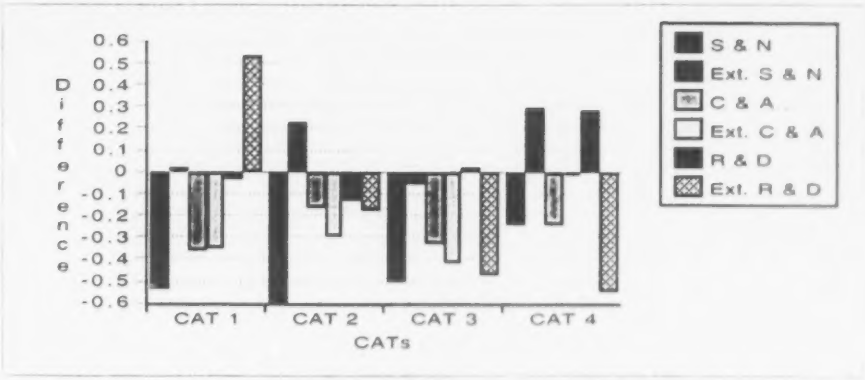

Figure 2. Difference between country and metropolitan CAT scores for all subjects.

From Figure 2 the bars that fall below the axis represent CATs in subjects where metropolitan students have outperformed their country counterparts. There are eighteen instances in which metropolitan students have outperformed their country counterparts, and only six instances in which the country students have outperformed their metropolitan counterparts.

MANOVA results for regional effect are summarized in Table 7. Five of the six tests were significant.

Table 7. Results of the MANOVA for the Region (Country vs. Metropolitan) Effect in the Six Units 3 and 4 VCE Mathematics Subjects

Subject	d.f.	F (Exact)
S&N	4, 6642	35.2 **
Ext. S&N	4, 4103	14.3 **
C&A	4, 5740	9.2 **
Ext. C&A	4, 10013	43.0 **
R&D	4, 12634	25.7 **
Ext. R&D	4, 123	2.3

* adjusted $p \leq 0.05$ ** adjusted $p \leq 0.01$

For the five subjects displaying a significant regional effect, the corresponding univariate results are summarized in Table 8.

Table 8. Results of the Univariate Tests for Region Effect on Achievement for each CAT in each of the Five Significant Subjects

		Univariate F values			
Subject	d.f.	CAT 1	CAT 2	CAT 3	CAT 4
S&N	1, 6645	63.3 *m	72.2 *m	61.8 *m	5.7
Ext. S&N	1, 4106	0.0	6.7	1.0	18.3 *c
C&A	1, 5743	29.8 *m	5.8	17.9 *m	9.8 *m
Ext. C&A	1, 10016	48.5 *m	39.3 *m	52.2 *m	0.0
R&D	1, 12637	1.0	11.8 *m	0.1	30.1 *c

* adjusted $p \leq 0.05$ (c country students advantaged; m metropolitan students advantaged)

The univariate F-tests show that for the five subjects displaying a significant multivariate regional effect, each of CAT 1, 2, 3 and 4 has three of the five subjects with significant univariate statistics. Of the twelve significant univariate differences in country versus metropolitan performance on CATs, only two of these are in favour of the country and both are for CAT 4, a standard examination CAT.

(c) Intra-regional Differences between males and females in Country and Metropolitan schools

Tables 9 and 10 contain the average female and male grades for each of the CATs broken down by metropolitan and country areas.

Table 9. Female and Male CAT Grades for Metropolitan Students.

	CAT 1		CAT 2		CAT 3		CAT 4	
Subject	F	M	F	M	F	M	F	M
S&N	4.89	4.80	5.40	5.54	5.13	5.76	3.99	5.00
Ext. S&N	4.30	3.57	4.83	4.08	2.97	2.64	3.17	2.93
C&A	6.38	6.03	6.56	6.42	5.34	5.62	6.18	6.29
Ext. C&A	6.80	6.27	6.86	6.71	5.88	6.04	5.62	6.08
R&D	5.50	5.21	5.95	6.06	5.71	6.09	4.42	4.99
Ext. R&D	5.40	5.32	6.56	5.78	3.21	3.37	4.72	5.29

Table 10. Female and Male CAT Grades for Country Students.

	CAT 1		CAT 2		CAT 3		CAT 4	
Subject	F	M	F	M	F	M	F	M
S&N	4.64	3.91	5.09	4.63	4.83	5.15	3.92	4.72
Ext. S&N	4.48	3.40	5.04	4.31	2.84	2.67	3.28	3.41
C&A	6.21	5.42	6.47	6.19	5.09	5.21	5.94	6.06
Ext. C&A	6.52	5.84	6.57	6.42	5.37	5.68	5.58	6.11
R&D	5.55	5.15	5.99	5.82	5.77	6.08	4.68	5.27
Ext. R&D	7.12	4.56	6.71	5.13	3.24	2.40	4.35	4.67

The patterns across subjects and CATs, for country and metropolitan students, are best shown graphically in Figures 3 and 4 by plotting the difference (female mean minus male mean) in CAT scores for each CAT within each study.

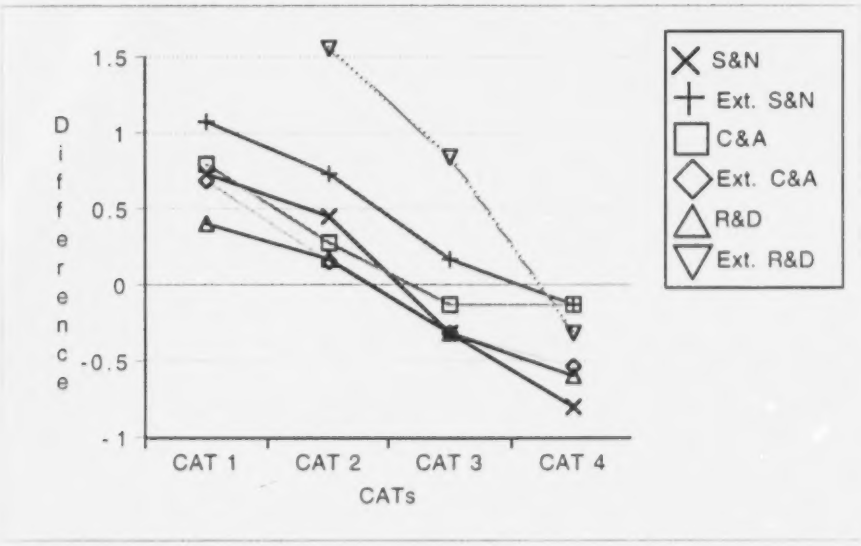

Figure 3. Graph of difference (female average CAT score minus male average CAT score) for each CAT, by subject, for country students.

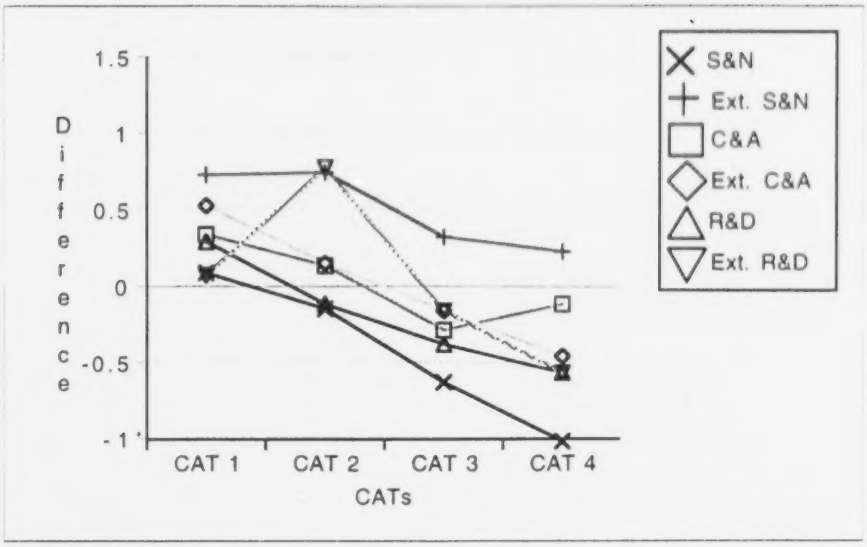

Figure 4. Graph of difference (female average CAT score minus male average CAT score) for each CAT, by subject, for metropolitan students.

In comparing Figure 1 with Figures 3 and 4, it appears that the country females are performing marginally better than country males relative to the metropolitan differences between the females and the males. However, the same downward trend observed in Figure 1 is apparent in both country and metropolitan students.

The MANOVA results on intra-regional gender differences for both country and metropolitan regions were significant (adjusted $p \leq 0.01$) for all subjects except Ext. R&D.

The results of the separate Country and Metropolitan univariate tests for sex effect on achievement for each CAT in each of the five significant subjects for country and metropolitan students are summarised and compared to the overall univariate tests, from Table 4, in Table 11.

These results support the findings from the graphical observations. Country female students appear to be performing significantly better than country males in more subjects for CAT 1 and 2 than metropolitan females do compared to metropolitan males. However, similar effects across the four CATs seem to be occurring in both the country and metropolitan regions, as seen in Figures 3 and 4.

Table 11. Summary of the Number of Univariate Results Significantly Favouring Females and Males from Table 4 (Overall Population) Compared with Table 4.26 (Country) and Table 4.28 (Metropolitan) [Note: 4/6F means four of the six subjects had a significant (adjusted $p \leq 0.05$) sex effect on achievement in favour of females]

	CAT 1	CAT 2	CAT 3	CAT 4
Overall	4/6 F	3/6 F	1/6 F, 4/6 M	3/6 M
Country	5/6 F	2/6 F	3/6 M	3/6 M
Metropolitan	4/6 F	1/6 F, 2/6 M	1/6 F, 4/6 M	3/6 M

(d) Inter-regional Differences Between Males and Females in Country and Metropolitan Schools

To consider whether metropolitan and country differences are evenly distributed amongst male and female students, the differences between country and metropolitan students were calculated by gender. The differences were calculated by subtracting the average metropolitan CAT score for females or males from the average country CAT score for females or males. The results of this calculation are presented in Table 12.

Table 12. Differences Between the Average Country and Metropolitan CAT Scores for All Subjects, by Gender. (Positive values represent country students performing better)

	CAT 1		CAT 2		CAT 3		CAT 4	
	F	M	F	M	F	M	F	M
S&N	-0.25	-0.89	-0.31	-0.91	-0.3	-0.61	-0.07	-0.28
Ext. S&N	0.18	-0.17	0.21	0.23	-0.13	0.03	0.11	0.48
C&A	-0.17	-0.61	-0.09	-0.23	-0.25	-0.41	-0.24	-0.23
Ext. C&A	-0.28	-0.43	-0.29	-0.29	-0.51	-0.36	-0.04	0.03
R&D	0.05	-0.06	0.04	-0.24	0.06	-0.01	0.26	0.28
Ext. R&D	1.72	-0.76	0.15	-0.65	0.03	-0.97	-0.37	-0.62

The differences between country and metropolitan students across the subjects point to a possible advantage for metropolitan students over their country counterparts, especially considering that 69% (33/48) of the differences are in favour of metropolitan students.

The results of the multivariate tests of significance of the two-way interaction of region by sex are summarized in Table 13.

Table 13. Results of the MANOVA for the Region by Sex Interaction for the Six Units 3 and 4 VCE Mathematics Subjects

Subject	d.f.	F (Exact)
S&N	4, 6642	4.3 *
Ext. S&N	4, 4103	5.7 **
C&A	4, 5740	4.2 *
Ext. C&A	4, 10013	2.9
R&D	4, 12634	3.7 *
Ext. R&D	4, 123	1.8

* adjusted $p \leq 0.05$ ** adjusted $p \leq 0.01$

For the four subjects displaying a significant region by sex interaction, the univariate results are recorded in Table 14.

Table 14. Results of the Univariate Tests for Region by Sex Interaction on Achievement for each CAT in each of the Four Significant Subjects

		Univariate F values			
Subject	d.f.	CAT 1	CAT 2	CAT 3	CAT 4
S&N	1, 6645	9.0 *	8.8 *	1.0	0.1
Ext. S&N	1, 4106	7.0 *	0.5	0.0	3.5
C&A	1, 5743	12.8 *	2.5	2.9	0.4
R&D	1, 12637	1.4	4.7	0.1	2.7

* adjusted $p \leq 0.05$

The univariate region by sex interaction was significant for only S&N, Ext. S&N and C&A in CAT 1 and S&N CAT 2. Apart from the four significant univariate results, the remaining twenty two-way interactions of region by sex were not statistically significant. To further study this regional effect separate MANOVA tests were run for males and for females to assess regional differences. These MANOVA results and the corresponding univariate results for the subjects displaying significant sex interaction are recorded in Tables 15 through to Table 17.

Table 15. Results of the MANOVA for the Regional Effect in the Six Units 3 and 4 VCE Mathematics Subjects for Females and males

	females		males	
Subject	d.f.	F (Exact)	d.f.	F (Exact)
S&N	4, 3349	7.1 **	4, 3320	27.1 **
Ext. S&N	4, 2148	3.9 *	4, 1974	15.1 **
C&A	4, 3258	1.9	4, 2507	10.0 **
Ext. C&A	4, 3896	18.6 **	4, 6144	26.1 **
R&D	4, 5693	6.4 **	4, 6967	22.5 **
Ext. R&D	4, 59	2.8	4, 73	0.7

* adjusted $p \leq 0.05$ ** adjusted $p \leq 0.01$

Table 16. Results of the Univariate Tests for Region Effect on Achievement for each CAT in each of the Four Significant Subjects for Female Students

		Univariate F values			
Subject	d.f.	CAT 1	CAT 2	CAT 3	CAT 4
S&N	1, 3352	6.7	7.8 *m	10.2 *m	0.4
Ext. S&N	1, 2151	1.6	3.0	1.4	1.1
Ext. C&A	1, 3899	8.9 *m	14.5 *m	26.5 *m	0.3
R&D	1, 5696	0.9	0.1	0.4	11.6 *c

* adjusted $p \leq 0.05$ (c country students advantaged;m metropolitan students advantaged)

Table 17. Results of the Univariate Tests for Region Effect on Achievement for each CAT in each of the Five Significant Subjects for Male Students

		Univariate F values			
Subject	d.f.	CAT 1	CAT 2	CAT 3	CAT 4
S&N	1, 3323	51.0 *m	56.5 *m	31.4 *m	4.2
Ext. S&N	1, 1977	1.5	3.1	0.0	20.1 *c
C&A	1, 2510	29.9 *m	4.6	11.3 *m	3.5
Ext. C&A	1, 6147	38.3 *m	21.6 *m	19.3 *m	0.2
R&D	1, 6970	3.9	18.0 *m	0.8	10.0 *c

* adjusted $p \leq 0.05$ (c country students advantaged;m metropolitan students advantaged)

From Tables 15 to 17 it can be seen that there was a significant regional effect for females in some cases. Five univariate tests are significantly in favour of metropolitan students and only one is in favour of country students. It is interesting to observe that three of the significant differences for metropolitan females occurred in Ext. C&A.

However, for males there was a larger regional effect with nine univariate tests in favour of metropolitan students and only two in favour of country students. It appears that country males do not perform as well as metropolitan males in CATs 1 to 3. For both males and females CAT 4 (the closest to an old style examination) seems to be the fairest and in several cases statistically in favour of country students.

Discussion

1. Do Males Differ from Females in VCE Units 3 and 4 Mathematics with Respect to their Mean Performance on CATs 1 to 4 ?

(a) Participation of Males and Females in VCE Mathematics

The participation trends in Table 1 have revealed that although there were over four thousand more females than males enrolled at VCE Units 3 and 4 level in 1992 (28204 females, 24120 males), there were almost three hundred fewer females than males enrolled in at least one mathematics Units 3 and 4 subject. These overall enrolment trends are similar to those reported by Dekkers, De Laeter and Malone (1991) with respect to the proportions of males and females enrolled in Year 12 mathematics over the period 1970 to 1989.

Findings of comparable percentages of male and female enrolments in S&N, Ext. S&N, C&A and Ext. R&D are consistent with the results reported by Lydeamore (1993) and Teese et al. (1995) for non-specialist mathematics subjects. The much larger percentage participation of males in Ext. C&A is consistent with other findings (Cockroft 1982; Dekkers et al. 1991; Leder 1982; Leder 1990; Lydeamore 1993; MacCann 1995; Morton, Reilly, Robinson and Forbes 1994; Teese et al. 1995) for the specialist mathematics courses, with fewer females than males enrolling in these subjects.

(b) Gender Differences in Performance on the CATs

From the trends shown in Figure 1 and Table 4, it can be seen that females are generally outperforming males on CATs 1 and 2 and males are generally outperforming females on CATs 3 and 4. Also, females, relative to males, perform more poorly as one progresses from CAT 1 to CAT 4.

The MANOVA, and resultant univariate, results of gender differences in 1992 CAT

performance are confirmed by the pilot study work of Cox (1995) carried out on the summary data provided by the Victorian Curriculum and Assessment Board (VCAB, 1993) and by the work of Rowley, Leder and Brew (1994).

The univariate F-tests show that the observed trend of females doing better than males in CAT 1 is statistically significant at the 5% significance level for four of the six subjects. One of the subjects with no significant differences in three of the univariate tests had a small number of students, and was thus possibly unrepresentative of the general Year 12 student population. This subject is Ext. R&D which never made it as an accepted mainstream subject 'through a quirk of tertiary prerequisites' (Rowley et al. 1994, p. 8), had low enrolment numbers and was only offered by a handful of schools.

Although not as clear cut, CAT 2 still has females significantly outperforming males in three of the six subjects; although the F values are smaller than for CAT 1. Both CATs 1 and 2 are written pieces of assessment which involve significant amounts of work to be done over an extended period. Drafts of work can be submitted to teachers with the final piece being a written report. Females would appear to be more capable (on average) than the males in this area, possibly due to their good communication skills, their ability to apply themselves to an extended task and their conscientiousness and preparedness to seek help with drafts more frequently than males. This idea is supported in the literature with Rowley et al. (1994) suggesting that CATs 1 and 2 assess different skills, that are more language based, from the skills assessed in CATs 3 and 4. The finding of females performing better in school-based styles of assessment is consistent with findings from Lydeamore (1993), MacCann (1995), Parker in Rennie and Parker (1991), Stobart et al. (1992) and Whitehouse and Sullivan (1992)

In contrast to CAT 1, males are performing significantly better in CAT 3 than females (at the 5% significance level) in four of the six subjects. Females perform significantly better than males (at the 5% significance level) in Ext. S&N, while the only subject that was not significant (Ext. R&D) had a small (and possibly unrepresentative) population. Reviews by Sharma and Meighan 1980, Stobart et al. 1992, Whitehouse and Sullivan 1992 and Willis 1989, indicated that males consistently do better than females on multiple-choice items, and that this is not changing over time. Stobart et al. (1992) suggested that a factor in the males favour may be that they do not have to express themselves in English. This conjecture is supported by the relatively better performance of females in CATs 1 and 2 which required written communication.

CAT 4, although not as clear as CAT 3, still has three of the six subjects showing males significantly (at the 5% significance level) outperforming females. It is of interest to note that

in CAT 4 two non-significant differences are in the negative direction (male advantaged) and only one subject (Ext. S&N) has a non-significant difference in the positive direction (female advantaged). These findings for CAT 3 and CAT 4 add to the considerable body of evidence already existing that females are outperformed by males in Australian secondary school mathematics examinations, and that the gender differences in mathematics achievement at the age of 17 are consistently in favour of males (Adams 1985; Atkins, Leder, O'Halloran, Pollard and Taylor 1991; Daley 1985; MacCann 1995). However, CATs 1 and 2 do seem to challenge these findings and add to the growing evidence (Lydeamore 1993; MacCann 1995; Parker in Rennie and Parker 1991; Stobart et al. 1992; Whitehouse and Sullivan 1992) that the use of school-assessed components in senior secondary mathematics tends to favour females over males.

2. Do Males Differ from Females in VCE Units 3 and 4 Mathematics with Respect to their Mean Performance on CATs 1 to 4 when the Location (Country Versus Metropolitan) of their Schools is Taken into Account?

(a) Participation of Country and Metropolitan Males and Females in VCE Mathematics Units 3 and 4 Subjects

In VCE Units 3 and 4 metropolitan females and males outnumbered their country counterparts by a ratio of three to one, and as one would expect there was a similar ratio in the mathematics enrolments of country and metropolitan students. However, in terms of percentages of their respective country or metropolitan overall enrolment, there were more metropolitan students enrolled in four of the six mathematics subjects. This is of particular interest since C&A and Ext. C&A, the two major calculus subjects, were amongst these four subjects. This finding is consistent with Teese, Charlton and Polesel (1994) who found lower participation by country students in mathematics, particularly in the more demanding subjects.

Similar ratios of male percentage to female percentage from country and metropolitan regions were present in the six subjects with no obvious trend between the two regions in terms of gender across all subjects.

(b) Differences Between Student Performance in Country and Metropolitan Regions

Figure 2 displayed the difference between the country and metropolitan average scores for each CAT in the six subjects. Country students performed better than their metropolitan counterparts in only six out of twenty-four CATs. Of these, only two were statistically significant. In comparison, metropolitan students performed better than their country counterparts in eighteen of the twenty-four CATs. Of these, ten were statistically significant.

These findings are consistent with the work of Teese et al. (1995) and Whitehouse and Sullivan (1992) on other Australian mathematics and science examination results. These writers found that country students generally had lower performance levels than metropolitan students. Perhaps the socio-cultural explanation, suggested by Methen and Wilkinson (1988), Randhawa (1988), and Swetz et al. (1983) is a reasonable explanation of these differences in mathematics achievement between metropolitan and country students. Another explanation suggested by Whitehouse and Sullivan (1992), and discussed earlier, was one of inequality of opportunity for country students. This alternative explanation was a criticism, made by country teachers, of the first two mathematics CATs in the VCE. They argued that country students were disadvantaged, compared with their metropolitan peers, by a lack of resourcing, networks and training in place in the country to assist teachers in coping with such forms of assessment. This argument may be a reasonable explanation to account for some of the differences observed between country and metropolitan average achievement, particularly when the major proportion of the significantly better metropolitan performance occurred on the first three CATs. Only in CAT 4, the traditional style of examination, did the country students perform significantly better than their metropolitan peers. This is strong evidence that the country students were in fact disadvantaged in the new forms of assessment, perhaps because of an inequality of opportunity, for such things as resources and support, that Whitehouse and Sullivan (1992) have suggested exists for such students.

(c) Intra-regional Differences Between Males and Females in Country and Metropolitan Schools

Figures 3 and 4 seemed to illustrate that the country females were performing better than country males relative to the metropolitan differences between females and males. The results of the statistical tests, summarized in Table 11, suggest that there is a small amount of evidence indicating that country females are performing better than country males in more subjects in CAT 1 and CAT 2 than their metropolitan counterparts. However, this evidence is minimal and generally speaking, intra-regional gender differences in performance are similar to differences observed in the overall state population. This finding, unlike the differing intra-regional gender performances reported by Randhawa (1988) between rural and metropolitan students, may be due to a lack of socio-cultural regional differences among Victorian students.

(d) Inter-regional Differences Between Males and Females in Country and Metropolitan Schools

The calculated differences between country and metropolitan males and females pointed to a possible advantage for metropolitan students with 69% of the differences in favour of metropolitan students. The MANOVA results for region by sex interaction displayed four subjects with significant differences. Four of the univariate tests indicated that there was a statistically significant effect. Because of the closeness of metropolitan male and female grades, one possible explanation might be that country males did not perform as well as country females when compared with their metropolitan equivalents.

The males and females were separated and MANOVA tests run separately for both groups. From these tests it appeared that metropolitan females performed significantly better than country females in five instances for CATs 1 to 3 and country females performed significantly better than metropolitan females in one instance in CAT 4. Three of the five significant metropolitan female performances occurred in Ext. C&A, the most demanding mathematics subject. The same tests for males displayed that metropolitan males performed significantly better than country males in nine instances for CATs 1 to 3 and country males performed significantly better than metropolitan males in two instances in CAT 4. These findings support the earlier suggestion that country males do not perform as well as country females when compared to their metropolitan counterparts. These findings add further weight to the finding from Section 2 (b) that the style of assessment used on CATs 1 to 3 in 1992 appears to have favoured the metropolitan students, and that the traditional examination style of CAT 4 was the only style of assessment that lacked a regional inequality of opportunity.

Conclusions

The study of differential performance cannot be viewed without an understanding of underlying participation differences. This study has identified groups of mathematics students who participate more or less in mathematics subjects and perform better or worse with variations caused by the method of assessment.

Statistical tests on large populations have been employed in this study, and as Walkerdine (1989) warns 'in large surveys trivially small differences may be highly significant statistically, and this significance may be deceptive' (p. 14). The statistical significance of these findings needs to be related to educational significance. The size of the differences reported, and the conservative estimates used in significance testing, point to educationally significant differences where statistical differences are found.

The findings from this study indicate that females are not as disadvantaged in VCE mathematics assessment as they have been in earlier mathematics courses in Victoria. The largest disadvantage occurs for females in terms of participation, particularly in double-mathematics courses and advanced mathematics subjects. This study has shown, as have Rowley et al. (1994) and Teese at al. (1995), that females performed significantly better than males in most subjects on CATs 1 and 2, while males performed significantly better than females in more subjects on CATs 3 and 4. The different forms of assessment known as internally assessed CATs and test CATs appear to measure different mathematical skills. This innovation in mathematics assessment in the VCE took a step backwards in 1993 when CAT 2 was removed for verification reasons.

Consistent with the findings of Teese et al. (1994) and Teese et al. (1995), it appears that country students have been disadvantaged compared with metropolitan students, and this study has found this disadvantage to occur mainly in CATs 1, 2 and 3, and more particularly for males. The inequality of opportunity proposed by Whitehouse and Sullivan (1992) for country students has been demonstrated to have some validity in CATs 1, 2 and 3. It is possible that differential selection of mathematics may account for some of the observed differences. However, as country students performed relatively better on CAT 4, some other effect appears to be operating. The regional performance differences found for the newer forms of assessment may have been caused by more limited access to resources and training for teachers in country schools. Perhaps the Directorate of School Education Victoria should study this effect further and develop some regional training and resourcing initiatives to overcome such imbalances.

Male students are perhaps becoming the new underclass in schools (Messina 1995) and it could be argued that this study adds evidence for such a view. The finding that females, when compared to males, under-enrol in mathematics, particularly in advanced mathematics courses, is a problem. However, the over-enrolment by males in mathematics is just as much of a problem, and less capable males pay the price in grades for doing this. The societal pressures that impact on males' course choices mean that they, perhaps as much as females, are restricted, and like Alice in Wonderland (Kenway and Willis 1993) must wake up to be saved from pathways that limit their career and university possibilities.

Techniques need to be researched and developed to help males improve their written communication skills and to help males, and females, select more appropriate subjects in Year 12. Initiatives are in place to assist females and these initiatives need to be further developed, particularly to find further ways to encourage females to take the more specialised

mathematics subjects. However, males do appear to be neglected and their plight is demonstrated by the major trends in this study. Males in Victorian senior secondary schools need help!

Finally, the possible disadvantage for country students in CATs 1, 2 and 3 needs to be more fully investigated, to determine if the effect is still present. If such an effect is still found to be present, then regional training and resourcing initiatives need to be developed to overcome such imbalances. Resourcing and training may be able to bring teachers and students from the country and city closer together. Tools currently being introduced to all Victorian schools, such as the internet and satellite communications, may prove to be particularly effective.

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